The Union of Soviet Socialist Republics

(19) SU (11) 1527022 A1

(51) 4 B 60 G 25/00

State Committee for Inventions and Discoveries GKNT of the USSR (State Committee for Science and Technology)

INVENTION DESCRIPTION

For author certificate

(21) 4421267/31-11

(22) 25.02.88

(46) 07.12.89 Bulletin #45

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(53) 629.113.012.82 (088.8)

(56) Author certificate USSR # 1150103, B 60 G 25/00, 1983

(54) SYSTEM FOR CONTROLLING MULTI-SUPPORT VEHICLE WITH ACTIVE SUSPENSIONS

(57) The invention relates to active suspension systems for vehicles, specifically to the equipment for controlling active suspensions. The objective of this invention is to increase the range of functional features through improved smooth motion and stability. The device contains vehicle speed sensors 1-7, relative displacement transducers for sprung and unsprung masses of right and left front suspensions, sensors monitoring changes in statistical weight of the vehicle, acceleration of the unsprung mass of the front suspension, angles of the longitudinal and rolling bank of the vehicle, as well as blocks 11 and 12 for identifying longitudinal and rolling stability, and equipment for mating the sensors and actuators of the suspension with these blocks. The control signal for the suspension is created in accordance with measurements of relative displacement transducers, motion speed, and acceleration of the unsprung mass; this signal is corrected in accordance with angular-data transmitters and sensors monitoring changes in statistical weight. The control signal originates in the blocks responsible for monitoring stability and is linked to the current time through the timer signal. [*Illegible*] 3.

The invention is related to active suspension systems for vehicles, specifically to the equipment for controlling active suspension systems.

The objective of this invention is to increase the range of functional features through improved smooth motion and stability.

Figure 1 shows a schematic of the control system for active suspension systems of a multi-support vehicle, Figure 2 is a structural schematic of the block responsible for monitoring stability; Figure 3 is a schematic of the algorithm of the functionality of the control system.

The control system for active suspension systems of a multi-support vehicle includes relative displacement transducers 1 and 2; X1 and X2 – sprung and unsprung masses for front right and left suspensions, of the inductive type, sensor 3, for angle α of the longitudinal bank of the vehicle, of the pendulum type, sensor 4, for monitoring changes ΔG in statistical weight of the sprung body of the vehicle, of the strain-gauge type, sensor 5 of angle φ, for rolling bank of the vehicle, of the pendulum type, sensor 6, for speed V of the vehicle, of the tachometric type, which changes speed along with the number of rotations of moving parts in the power transmission, and sensor 7 which monitors acceleration $\dot{X}$ of the unsprung mass of the front suspension of the vehicle.

The outputs of sensors 1 and 2 are connected to the inputs of summing amplifier 8; its output and the outputs of sensors 3-7 through low-frequency filters 9 are connected to the input of block 10 of the analog-to-digital converter (A/D).

Each of analog-to-digital converters in block 10, together with low-frequency filters 9, sensors 1-7 and summing amplifier 8, create channels for measuring the difference of relative displacements ΔX of sprung and unsprung masses of the front right and left suspensions, angle α of the longitudinal bank of the vehicle, measurement ΔG of the statistical weight of the sprung body of the vehicle, angle φ of the rolling bank of the vehicle, motion speed V of the vehicle, and acceleration $\dot{X}$ of the unsprung mass of the front suspension of the vehicle.

In block 10 uninterrupted signals from sensors 3 -7 from the output of the summing amplifier are transformed into digital code.

The outputs of the analog-to-digital converter (A/D) are connected correspondingly with blocks 11 and 12, responsible for monitoring longitudinal and rolling stability; block 11 responsible for measuring longi-

tudinal stability is connected to the outputs of the analog-to-digital converter along the channels measuring angle α of the longitudinal bank, measurement ΔG of the statistical weight of the sprung body, motion speed V of the vehicle and acceleration $\ddot{X}$ of the unsprung mass of the front suspension of the vehicle. Block 12, responsible for measuring rolling bank, is connected to the outputs of the analog-to-digital converter along the channels measuring ΔG of the statistical weight of the sprung body, angle φ of rolling bank, motion speed V of the vehicle, and difference of relative displacement ΔX of sprung and unsprung masses of the front right and left suspensions.

Blocks 11 and 12 are designed to calculate the net component forces, applied to the sprung body, in its function of changing the measured parameters in accordance with known dependencies, programmed into the memory, and for consecutive summation of the values of specified applied forces. These blocks are also necessary for creating signals, compensating for road disturbances.

The structural schematics of blocks 11 and 12 are completely identical and only have different inputs. The measured values of α, ΔG, V, and X are entered into block 11 for measuring longitudinal stability, and the measured values of ΔG, φ, V, and ΔX are entered into the block for measuring rolling bank stability.

Blocks 11 and 12, used for measuring stability, are connected to timer output 13, used to create time intervals, to identify moments of controlled actions depending on the motion speed of the vehicle and disturbance type.

The outputs of block 11 measuring longitudinal and block 12 measuring rolling (lateral) stability are connected correspondingly to digital-to-analog converters (D/A) of longitudinal stability 14 and lateral stability 15.

Output D/A's 14 and 15 are connected to the inputs of control block 16 responsible for creating the required amplitude and duration of the control signals sent to additional mechanisms in the suspension.

The block for monitoring stability of the vehicle (Figure 2) is a microprocessor with memory, 17.

The microprocessor includes buffer circuits for input, 18 and output, 19, arithmetic-logic unit 20 (A/L), control unit 21, coupling unit 22 and unit of controlling register, 23. Memory 17 includes on-line memory and permanent fixed memory.

The memory has programs for calculating the net component forces applied to the sprung body from the side of the suspension parts depending on the measured parameters, assigned values of the measured parameters, and a program for determining the control action required to be applied to the actuators on the suspension to prevent oscillations caused by road disturbances.

The arithmetic-logic unit carries out logic and arithmetic operations with the measured values.

The control unit produces the required control signals for inputting initial data into the buffer circuit of the input, access of the next-in-line command and data from memory, deciphering of the command code, access of subroutines from memory, data transfer from the arithmetic-logic unit to the memory and through the coupling unit to the buffer circuit of the input to outside units, in the present case to the input of a digital-to-analog converter.

The control registers unit is designed for temporary storage of the control information and contains registers and gauges engaged in controlling the computational process.

The coupling unit organizes information exchange between the processor and the on-line memory, as well as with the equipment located outside the microprocessor.

The control system of the active suspension systems of the multi-support vehicle performs in accordance with an algorithm; its schematic is presented in Figure 3.

When the vehicle moves along a smooth surface, the signals from sensors 1,2, and 7 correspond with the assigned values and no control signal is generated because the front suspension is in a state of rest.

As soon as the front suspension encounters an uneven surface, an error signal is generated between the values coming from sensors 1, 2, and 7, values ΔX and $\dot{X}$ with their assigned values in the microprocessor. Value $\dot{X}$ is sent to unit 11, which measures longitudinal stability, from its measurement channel, and ΔX is sent to unit 12, which measures lateral stability, where suspension control signals are generated to compensate longitudinal and lateral disturbances.

Based on the values of the generated control signals of the front suspension system, the control signals for the second and sequential suspensions are generated according to the following formula.

Let L to be the distance between neighboring axles of the vehicle (for simplicity considerations, assume it is equal for all axles), y is the motion speed of the vehicle and t_{cp} is the response time of the actuator on the suspension, and $U_1(t)$ is the control signal of the first suspension.

Then the control signal for the second suspension:

$U_2(t) = U_1\,(t - t_{mo} + t_{cp})$,

The third suspension,

$U_3\,(t) = U_1\,(t - 2\,t_{mo} + t_{cp})$,

i of the suspension

$U_i(t) = U_1(t - (i-1)\, t_{mo} + t_{cp})$,

Where i is the consecutive number of a vehicle axle, i = 1, n

n is the number of the vehicle axles

t_{mo} is the time it takes the vehicle to cover the distance between axles t_{mo} = L divided by V

Timer 13 is used to link to the current time.

To avoid error accumulation, feedback relative to signals from sensors 3-5 is used in the control system, the control signal of the suspension is corrected based on the collected signals α, ΔG and φ, to ensure that α, ΔG and φ accept the assigned values programmed into the microprocessor memory.

Invention Formula

The control system of the active suspension systems of a multi-support vehicle, with a sensor for a longitudinal bank, a sensor for a lateral roll, a sensor for measuring changes in the statistical weight of a sprung body of the vehicle, a speed sensor of the vehicle, with all outputs of specified sensors through low-frequency filters are connected to inputs of the analog-to-digital converters, which together with the above-mentioned filters and sensors create the channels of measurements of the above-mentioned values, when the outputs of analog-to-digital converters along the measurement channels of the angle of longitudinal bank, changes in statistical weight of the sprung body and motion speed of the vehicle are connected with the unit for measuring longitudinal bank of the vehicle, connected to the digital-to-analog converter of longitudinal stability, and the outputs of analog-to-digital converters from the measurement channels of the statistical weight of the sprung body, angle of lateral roll and motion speed of the vehicle are connected to the unit measuring lateral stability of the vehicle, connected with the digital-to-analog converter of lateral stability, which is different, because due to its objective to increase the range of the functional features through improved smooth motion and stability, it is equipped with additional sensors of relative displacement transducers of sprung and unsprung masses of the right and left front suspension, acceleration of the unsprung mass of the front suspension, summing amplifiers and timer, with outputs of a relative displacement transducer connected to inputs of the summing amplifier, and its output and the output of the acceleration sensor of unsprung mass of the front suspension through low-frequency filters are connected to the analog-to-digital converters, which together with the specified filters, sensors and summing amplifier create channels of measurement of the differences of relative displacements of sprung and unsprung

masses of front right and left suspensions and acceleration of unsprung mass of the front suspension, with outputs of analog-to-digital converters along the measurement channels of the difference of relative displacements of sprung and unsprung masses of the front right and left suspension are connected with the block measuring lateral stability, and the outputs of analog-to-digital converters from the measurement channels of the difference of relative displacements of the unsprung mass of the front suspension are connected with the block measuring longitudinal stability, the timer outputs are connected to inputs of blocks for measuring longitudinal and lateral stability, and outputs of digital-to-analog converters for measuring longitudinal and lateral stability are connected to the summing amplifier.

FIGURES

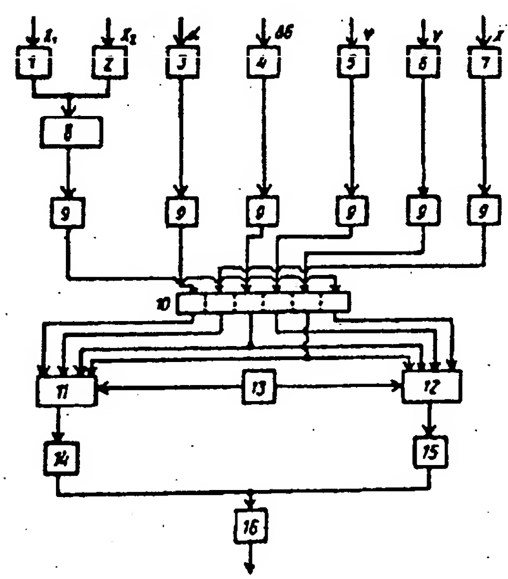

Fig.1

FIGURES

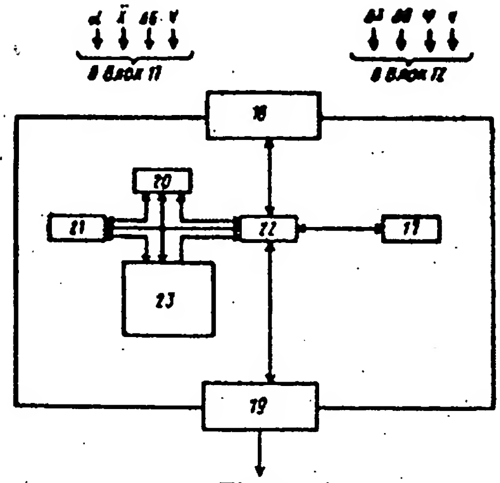

Fig. 2

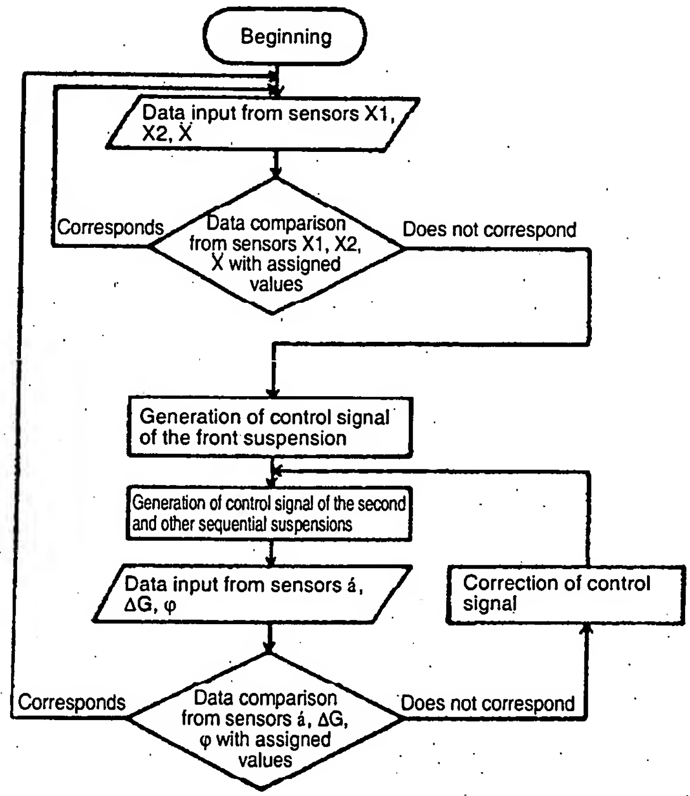

Fig. 3

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Editor A. Shandor | Technical Editor M. Khodanich | Corrector S. Cherni

Order 7458/22 | Circulation 528 | Subscribed

VNIIPI State Committee for Inventions and Discoveries State Committee of Science and Technology of the USSR

113035, Moscow, Zh-35, Raushskay embankment, building 4/5

Production-printing enterprise "Patent" Uzhgorod, Gagarin street, 101

Translated by Japan-America Management, Ltd. Ann Arbor, Michigan